**Supplement 2: Test 2 and associated teacher’s notes**

[**MTA-ELTE Research Group on Inquiry-Based Chemistry Education**](https://mta.hu/kozoktatas-fejlesztesi-kutatasi-program/scientific-foundations-of-education-research-program-of-the-hungarian-academy-of-sciences-111618)

[**Research Programme for Public Education Development of the Hungarian Academy of Sciences**](https://mta.hu/kozoktatas-fejlesztesi-kutatasi-program/research-programme-for-public-education-development-of-the-hungarian-academy-of-sciences-111934)

*Note: More detailed instructions are available in Hungarian in the teacher’s guides, under the title “*[T1 teszt és javítási útmutatója](https://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBbE1NIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--e84ad04b40e9b3a55c316097b1f71bddd2c7f910/T1_teszt_2022_08_30_UTMUTATO_HONLAPRA.docx?disposition=attachment)*” for T2 at* [*https://ttomc.elte.hu/publications/92*](https://ttomc.elte.hu/publications/92)

Test 2 (May, 2023)

Number of school:…(A) Number of teacher:…(B) Number of group:…(C) Number of student: …(D)

The aim of our research is to make the teaching of chemistry as interesting and effective as possible.

Thank you for completing this test to the best of your ability. This will help our work considerably. Write your answers on this sheet of paper. Please do not use any other paper.

1. a) Which ions cause the hardness of water?

AY

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1. b) Why is baking soda not suitable for water softening?

AZ

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2. Imagine you are on holiday with relatives in a small village and you have filled a swimming pool in the yard with water. **The water needs to be disinfected with a tablet that can work in the pH=7-8 range, but the pH of the local water is higher than 8.** There is a chemical that needs to be added to the pool in such quantities that the bathing water reaches the desired pH range. However, the test strip to check the pH of the water is out of stock and is only available in a remote town. Remember, however, that red cabbage juice can act as an acid-base indicator and can be made from cabbage at home. According to the Internet, red cabbage juice is yellow at pH ≥12, green and greenish blue around pH=9-11, blue between pH=7-8, lilac or purple between pH=4-7, and red in the pH≤3 range. **This allows you to adjust the pH of the pool water to the pH range that the disinfectant tablets will work.** You cannot pour the cabbage juice into the pool, but you can use cups to take a water sample from the pool, even several times. There is also a shovel to mix the water in the pool. **Use your answers below to help design the experiments to get the right pH range.**

a) What can you change about the **total contents** of the pool during the experiments (i.e. what should be added to the total contents of the pool in each experiment)?

BA

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b) What property of the pool water depends on the change you cause?

BB

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c) How can you test for this property of the pool water mentioned in 2. (b) above?

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BC

d) From what observation can you conclude that more material needs to be added?

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BD

e) Why is it always important to mix the pool water carefully?

BE

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f) In which case can you conclude that you can now put the disinfectant tablets in the pool water?

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BF

g) Put a (**+**) sign in front of the statement(s) in the list below that is/are important and a (**-**) sign in front of the statement(s) that is/are not important (You can write a different sign after a clear strike-through if you change your mind.)

BG

The water should be always taken out from the same point in the pool by the cup.

Always the same volume of water should be taken out from the pool by the cup.

BH

Always the same cup should be used to take out the water from the pool.

BI

3. a) Write down the chemical formula of slaked lime!

BJ

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3. b) Why does lime water get cloudy when you blow into it through a pipe?

BK

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4. a) The majority of gutters are made of iron (Fe) sheet coated with a layer of zinc (Zn). In the reduction series below, the reducing power decreases from left to right. Which of these is oxidised first, zinc or iron, when the sheet is damaged? **Why?**

K, Ca, Na, Mg, Al, Zn, Fe, Sn, **H**, Cu, Hg, Ag

BL

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4. b) The submerged hulls of tanker ships are covered with iron plates. Why can iron (Fe) be protected from corrosion by connecting it to a magnesium (Mg) rod by a metal conductor? Explain your answer using the reduction series in question 4. (a).

BM

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5. Why do you get thirsty after eating all those salty crisps?

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BN

6. Write down the **balanced** reaction equation for removing scale with household hydrochloric acid.

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BO

7. One website says: "*Glucose - Used to determine blood sugar levels, elevated levels indicate diabetes. The normal value is 0 mmol/l*." What is wrong with this claim? Justify your answer!

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BP

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Please also answer the following questions!

BQ

* Write your end of first term grade in 8th grade chemistry in the box:
* The bigger the number you circle, the more you like chemistry.

(0: you do not like it at all, 5: you really like it):

BR

1 2 3 4 5

* The bigger the number, the more you consider it important to test ideas in sciences by experiments (0: not important at all; 5: very important)

BS

1 2 3 4 5

* The bigger the number, the more you agree with the following statement:

“I prefer the step-by-step experiments to the ones that I have to design.”

BT

1 2 3 4 5

Instructions given to the teachers to mark the students’ answers of the Test 2

Please complete the columns of the Excel spreadsheet with the marks obtained from following the instructions below. A student’s marks should be written in the appropriate row of the Excel spreadsheet.

Columns AY-BP contain marks for students’ answers.

Columns BQ contains the student’s end of first term grade in 8th grade chemistry.

Columns BR-BT contain students’ attitude responses.

Abbreviations:

* DCK: disciplinary content knowledge;
* EDS: experimental design task

Column ‘AY’ (task 1.a)

If the expressions “calcium (ions) and magnesium (ions)” or any synonymous appear in the answer. Marks: 1

In any other case. Marks: 0

1 item: recall (DCK task)

Column ‘AZ’ (task 1.b)

“Because it does not precipitate ions that cause water hardness.” or any synonymous answer (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

Column ‘BA’ (task 2.a)

“The amount of chemical used to change the pH.” or any synonymous answer (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BB’ (task 2.b)

The pH/acidity or any synonymous answer (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0.

1 item: higher order cognitive skills (EDS task)

Column ‘BC’ (task 2.c)

If “the red cabbage juice or acid-base indicator” appear. Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BD’ (task 2.d)

“From the colour of the red cabbage juice.” or any synonymous answer (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BE’ (task 2.e)

“So that the content of the pool becomes homogeneous.” or any synonymous answer (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BF’ (task 2.f)

“From the blue colour (of the red cabbage juice/of the solution).” Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BG’ (task 2.g)

If the student put a “**-**” sign in front of the following sentence: “The water should be always taken out from the same point in the pool by the cup.” Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BH’ (task 2.g)

If the student put a “**-**” sign in front of the following sentence: “Always the same volume of water should be taken out from the pool by the cup.” Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BI’ (task 2.g)

If the student put a “**-**” sign in front of the following sentence: “Always the same cup should be used to take out the water from the pool.” Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘BJ’ (task 3.a)

If the following answer “Ca(OH)2” answer appears. Marks: 1

In any other case. Marks: 0

1 item: recall (DCK task)

Column ‘BK’ (task 3.b)

If “It forms a precipitate with carbon dioxide (in the exhaled air).” or any synonymous answer appears (see examples in the teacher’s guide). Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

Column ‘BL’ (task 4.a)

If any of the following or any synonymous answer appears:

“The zinc/Zn, because it has a higher reducing power/it is a stronger reducing agent (than the iron).”

“The zinc/Zn, because it can give off electrons more easily (than the iron).”

“The zinc/Zn, because it can be oxidised more easily (than the iron).”

“The zinc/Zn, because it is to the left in the reduction series (to the iron).”

Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

Column ‘BM’ (task 4.b)

If any of the following or any synonymous answer appears:

“The magnesium/Mg, because it has a higher reducing power/it is a stronger reducing agent (than the iron).”

“The magnesium/Mg, because it can give off electrons more easily (than the iron).”

“The magnesium/Mg, because it can be oxidised more easily (than the iron).”

“The magnesium/Mg, because it is to the left in the reduction series (to the iron).”

Marks: 1

In any other case. Marks: 0

1 item: application (DCK task)

Column ‘BN’ (task 5.)

If “Because the salt particles (sodium and chloride ions) must be surrounded by water (molecules/particles).” or “Because salt attracts water.” or any synonymous appears in the answer. Marks: 1

Marks: 0

1 item: application (DCK task)

Column ‘BO’ (task 6)

If

“CaCO3 + 2 HCl = CaCl2 + H2O + CO2 / CaCO3 + 2 HCl = CaCl2 + H2CO3” or

BO

“MgCO3 + 2 HCl = MgCl2 + H2O + CO2 / MgCO3 + 2 HCl = MgCl2 + H2CO3” or

both the above equationsappear in the answer. Marks: 1

In any other case. Marks: 0

1 item: application (DCK task)

Column ‘BP’ (task 7)

If “You cannot have a glucose concentration of 0 mmol/l (because there is always glucose in the blood).” or any synonymous appears in the answer. Marks: 1

In any other case. Marks: 0

1 item: application (DCK task)

Column ‘BQ’

The student’s end of first term grade in 8th grade chemistry.

Column ‘BR’

The answer given by the student to the question how much he/she likes chemistry. (Insert the number circled by the student.)

Column ‘BS’

The answer given by the student to the question how important he/she thinks it is in science to test ideas by experiments. (Insert the number circled by the student.)

Columns ‘BT’

The answer given by the student to the question: “The bigger the number, the more you agree with the following statement: »I prefer the step-by-step experiments to the ones that I have to design.” (Insert the number circled by the student.)

END OF EVALUATION OF THE TEST 2